REMARKS

Claims 27-54 are pending in this application. Claims 1-26 have been cancelled and claims 27-54 have been added by this amendment. Applicant reserves the right to reintroduce claims of comparable scope to the original claims in a continuation or other related application.

Applicant has amended the specification, abstract, and drawings to be in accord with the amended claims. No new matter has been added by these amendments.

Applicant believes that all pending claims are allowable and respectfully requests a Notice of Allowance from the Examiner. Should the Examiner believe that a telephone conference would expedite the prosecution of this application, the undersigned can be reached at the telephone number set out below.

Respectfully submitted,

James R. Riegel

Reg. 36,651

San Jose, California

408-467-1900

MARKED-UP VERSION OF AMENDMENTS

In the Specification:

Replace the paragraph starting on page 1, line 3, with:

The present invention relates to a computer-human interface device, and more particularly it relates to a stylus coupled to a supportable mechanical linkage for providing and receiving commands to and from a computer.

Insert on page 3, line 3, the following paragraph:

An embodiment of the present invention includes computer software and hardware which will provide force feedback information from the computer to the stylus. The computer sends feedback signals to the mechanical linkage which has force generators for generating force in response to images depicted on the computer screen. Incoming commands from the host computer are monitored by the microprocessor and instruct the microprocessor to report forces felt by a joint or set forces on a joint of the mechanical linkage.

Replace the paragraph starting on page 4, line 5, with:

Figure 3 is a flow chart describing the main software [loops] command loop for two different electronic hardware configurations shown in FIG. 2;

Insert on page53, line 12 after "apparatus", the following paragraph:

Also contemplated in the present invention is computer software and hardware which will provide feedback information from the computer to the stylus and cause forces on the stylus. This implementation is described in greater detail subsequently.

Replace the paragraph starting on page 5, line 21, with:

Because the stylus is supported by a support apparatus which is in turn supported by a fixed surface or other stabilizing configuration, the user can manipulate the stylus with a minimum of effort. Also, if the user chooses to discontinue using the stylus, it is capable of

maintaining its position in space, unattended. While FIG. 1 shows that preferred embodiment of the present invention, FIGS. 5-8 show alternative embodiments, such which are also contemplated under the present invention. It is preferable that the stylus have enough degrees of freedom to enable it to move through the mechanical linkage to give the user the amount of flexibility needed to move the cursor as desired. In FIG. 1, six degrees of freedom are shown and are labeled as [Axis' 16] Axes A1, A2, A3, A4, A5, and A6. This, of course, provides maximum flexibility. Fewer degrees of freedom, such as a plurality of degrees of freedom, may also be sufficient depending on the application.

Replace the paragraph starting on page 7, line 1, with:

As mentioned above, attached to each joint 12, 15 and 18 are sensors 13A, 13B, 16A, 16B, 19A, and 19B, respectively. These sensors sense the angle differential before and after motion of the two segments connected by that joint. The sensors can be, for example, optical incremental encoders, optical absolute encoders and potentiometers. Because the three-dimensional position and/or orientation tracking is achieved mechanically, this preferred embodiment avoids problems that magnetic and ultrasonic sensors, such as those shown in the prior art, encounter with metal and shadowing. However, as shown in FIG. 1, if desired, sensing means can be used to track the position and/or orientation of the stylus by mounting a single or several orientation sensors in the stylus 11 itself, such referred to as a stylus mounted sensor [11] 11'. An ultrasound, magnetic, optical or position and orientation sensor can be used as the stylus mounted sensor [11] 11'.

Replace the paragraph starting on page 8, line 1, with:

Referring to FIG. 2A, the sensors 13A, 13B, 16A, 16B, 19A and 19B, along with any peripherals 24, 25, or 26, can send their digital signals directly to a versatile floating-point processor or microprocessor 32A which is controlled by software stored in a digital ROM (Read-Only Memory) 35 via transmission line 32' or another form of transmission, i.e., radio signals. As shown in FIG. 2B, an alternative embodiment can be used to lessen the demands on the floating-point processor or microprocessor 32B. The digital inputs of the sensors 13A, 13B, 16A, 16B, 19A and 19B can be sent indirectly to the floating-point processor or microprocessor 32B by way of dedicated chips 13C, 13D, 16C, 16D, 19C and 19D, which pre-process the angle sensors' signals before sending them via bus 31 to the floating-point processor or microprocessor

32B which would combine these signals with those from the peripherals 24, 25 or 26. An 8-bit data bus plus chip-enable lines allow any of the angle determining chips to communicate with the microprocessor. Moreover, reporting the status of peripherals 24, 25 or 26 includes reading the appropriate digital switch and placing its status in the output sequence array. Some examples of specific electronic hardware usable for sensor pre-processing include quadrature counters, which are common dedicated chips that continually read the output of an optical incremental encoder and determine an angle from it, Gray decoders, filters, and ROM look-up tables.

Replace the paragraph starting on page 9, line 17, with:

Referring to FIG. 3, the main command loop responds to the host computer 34 and runs repeatedly in an endless cycle. With each cycle, incoming commands 40 from the host computer are monitored 36 and decoded 37, and the corresponding command subroutines for reporting angles, thus stylus position and/or orientation (see FIGS. 4A and 4B), are then executed 38. Two possible subroutines are shown in FIGS. 4A (single-chip method) and 4B (multi-chip method). When a subroutine terminates, the main command loop resumes 39. Available command will include but are not limited to: reporting the value of any single angle, reporting the angles of all six angles at one time, reporting the values of all six angles repeatedly until a command is given to cease aforementioned repeated reporting, reporting the status of peripheral buttons, and setting communications parameters. If the angle sensors require preprocessing, these commands will also include resetting the angle value of any single angle or otherwise modifying preprocessing parameters in other applicable ways. Resetting pre-processed angle values or preprocessing parameters does not require output data from the device. The microprocessor 32A or 32B simply sends appropriate control signals to the preprocessing hardware 13C, 13D, 16C, 16D, 19C, and 19D. If the microprocessor or floating-point processor is fast enough to [computer] compute stylus coordinates and orientation, these commands will also include reporting the stylus coordinates once, reporting the stylus coordinates repeatedly until a command is given to cease, ceasing aforementioned repeated reporting, reporting the stylus coordinates and orientation once, reporting the stylus coordinates and orientation repeatedly until a command is given to cease, and ceasing aforementioned repeated reporting. If force reflection is supported, these commands will also include reporting the forces felt by any single joint, setting the resistance of any single joint, and locking or unlocking a joint.

Replace the paragraph starting on page 10, line 13, with:

Any report by the subroutines of FIGS. 4A and 4B of a single angle value requires determining 41 the given joint angle. For the single-chip configuration shown in FIG. 2A, this subroutine directly reads the appropriate angle sensor 42 from among sensors 13A, 13B, 16A, 16B, 19A, and 19B. For the multi-chip configuration shown in FIG. 2B, this subroutine reads the outputs 43 of pre-processing hardware 13C, 13D, 16C, 16D, 19C, and 19D which have already determined the joint angles from the outputs of the sensors 13A, 13B, 16A, 16B, 19A, and 19B. Any report of multiple angles is accomplished by repeatedly executing the subroutine for reporting a single angle. The subroutine is executed once per angle, and the values of all angles are then included in the output sequence array. If the optional parts of the subroutines 45 are included, then these subroutines become the coordinate reporting subroutines. Many other command subroutines exist and are simpler yet in their high-level structure.

Replace the paragraph starting on page 10, line 13, with:

Any report by the subroutines of FIGS. 4A and 4B of a single angle value requires determining 41 the given joint angle. For the single-chip configuration shown in FIG. 2A, this subroutine directly reads the appropriate angle sensor 42 from among sensors 13A, 13B, 16A, 16B, 19A, and 19B. For the multi-chip configuration shown in FIG. 2B, this subroutine reads the outputs 43 of pre-processing hardware 13C, 13D, 16C, 16D, 19C, and 19D which have already determined the joint angles from the outputs of the sensors 13A, 13B, 16A, 16B, 19A, and 19B. Any report of multiple angles is accomplished by repeatedly executing the subroutine for reporting a single angle. The subroutine is executed once per angle, and the values of all angles are then included in the output sequence array. If the optional parts of the subroutines 45 are included, then these subroutines become the coordinate reporting subroutines. Many other [commend] command subroutines exist and are simpler yet in their high-level structure.

Replace the paragraph starting on page 10, line 25, with:

After determining the given joint angle, the microprocessor 32A or 32B creates an output sequence 44A or 44B by assembling an array in a designated area of processor memory 35 which will be output by the microprocessor's communications system at a given regular

communications rate. The sequence will contain enough information for the host computer 34 to deduce which command is being responded to, as well as the actual angle value that was requested. Returning to FIG. 3, a query 36 in the main command loop asks whether the previous command requested repeated reports. If so, the main command loop is initiated accordingly. The communications output process (not shown) may be as simple as storing the output data in a designated output buffer, or it may involve a standard set of communications interrupts that are an additional part of the software. Setting communications parameters does not require output data from the device. The microprocessor 32A or 32B simply resets some of its own internal registers or sends control signals to its communications sub-unit.

Replace the paragraph starting on page 11, line 14, with:

To report the stylus' 11 coordinates, three of the five or six angle values are pre-read and knowledge of link lengths and device kinematics are incorporated to compute stylus 11 coordinates. These coordinates are then assembled in the output sequence array.

Replace the paragraph starting on page 11, line 14, with:

To report the stylus' 11 orientation, at least five angle values are read and knowledge of link lengths and device kinematics are incorporated to [computer] compute stylus 11 orientation. The orientation consists of three angles (not necessarily identical to any joint angles) which are included in the output sequence array.

Replace the paragraph starting on page 11, line 18, with:

Forces felt by a joint are reported, and setting a joint's resistance, and locking or unlocking a joint are [reported] accomplished by using interaction of the microprocessor 32A or 32B with [forced] force-reflecting hardware [(not shown)]. Reporting forces felt by a joint uses a force sensor mounted on the joint and then places the resulting value in the output sequence array. To set a joint's resistance and [locking] lock or [unlocking] unlock a joint, control signals [reading from a force sensor to] are used to control force-reflection hardware [but] , and do not require any output data [of] from the device.

Replace the paragraph starting on page 11, line 25, with:

Also contemplated in the present invention is computer software and hardware which will provide feedback information from the computer to the stylus [(not shown)] , such as host commands 40 (shown in Fig. 1). This type of implementation is known in robotics and thus is easily incorporated into a system including the present invention. When a surface is generated on the computer screen, the computer will send feedback signals to the mechanical linkage which has force generators identified by numerals 13A, 13B, 16A, 16B, 19A, and 19B (which also identifies the sensors, see above) for generating force F (see Fig. 1) in response to the cursor position on the surface depicted on the computer screen. Force is applied for example, by added tension in the joints which is in proportion to the force being applied by the user and in conjunction with the image on the screen.

Replace the paragraph starting on page 12, line 16, with:

Briefly, FIG. 5 shows an embodiment having 6 rotary joints including a rounded joint 46 at the base such that three degrees of motion are available at that joint. FIG. 6 shows an embodiment having 5 rotary joints and one linear joint, including a three-dimensionally rotatable rounded joint 47 at the base through which one mechanical linkage can slide linearly and where the base is attached to a fixed surface 48 such that the surface does not prohibitively impede the movement of the device. FIG. 7 shows an embodiment having 3 rotary joints and 3 linear joints, where the basal connection can slide about the base in a two-dimensional plane in the cross configuration 49 on base 51. FIG. 8 shows an embodiment having 5 rotary joints and 3 linear joints, including three-dimensionally rotatable rounded joint 52 at a perpendicular projection from the base 53 through which one mechanical linkage 54 can slide linearly through the joint 52.

Replace the paragraph starting on page 12, line 25, with:

While any of the above discussed configurations or others can be used in accordance with the present invention, FIGS. 9-11 show different mechanisms for providing resistance to the manual manipulation of the stylus by the user. FIG. 9, for example, shows return or tension springs 56 on each joint of the embodiment shown in FIG. 1. In an alternative embodiment, FIG. 10, shows counter-weights 57 on each joint. Moreover, FIG. 11, shows a combination of a return

or tension spring 56, a [counter-wight] counter-weight 57 and a compression spring 58. The arrangement of the resistance mechanism used should depend upon the configuration stylus mechanical linkage combination, such arrangement preferably chosen to maximize the ease with which the user can manipulate the stylus 11 in free space in accordance with the present invention.

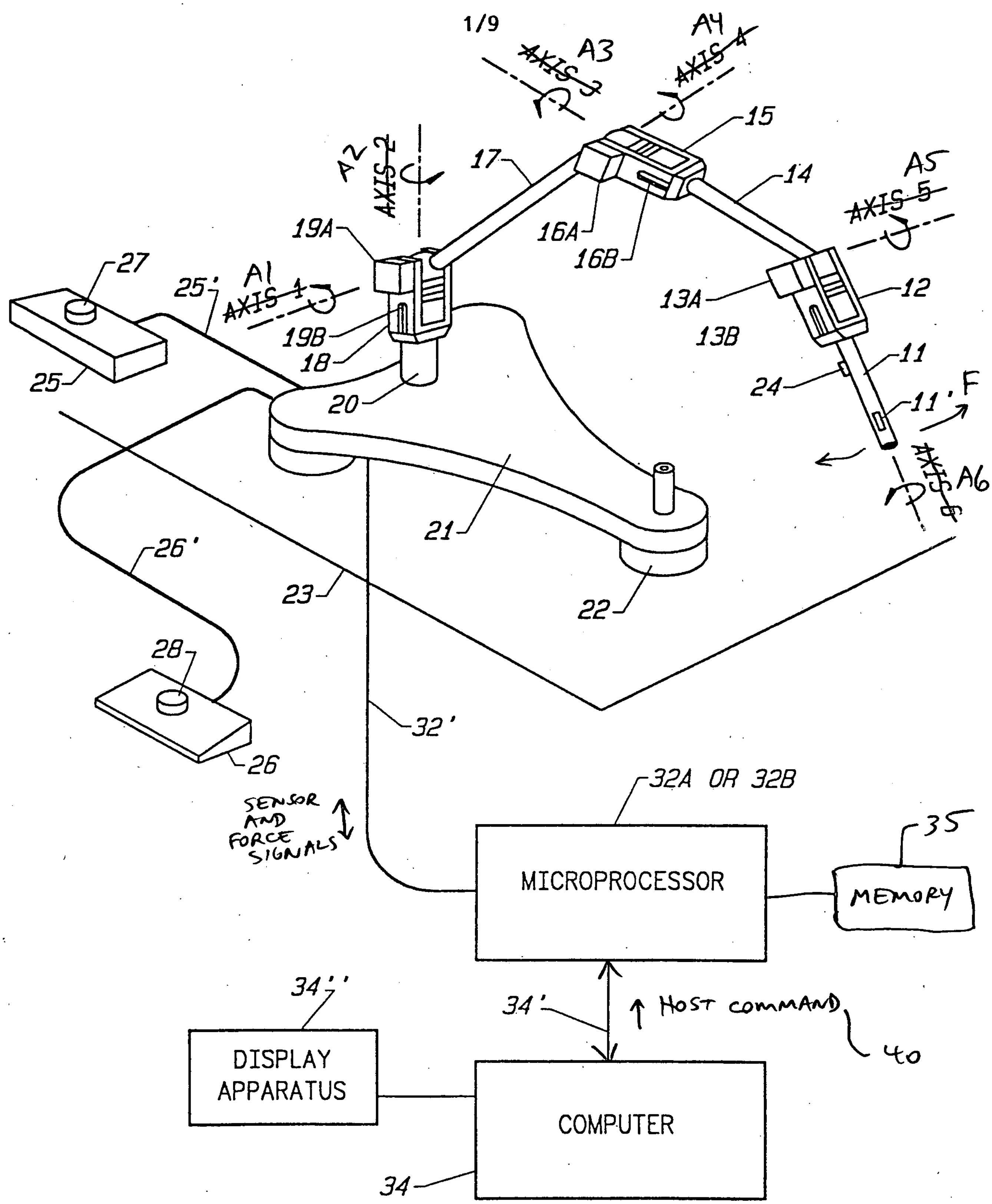
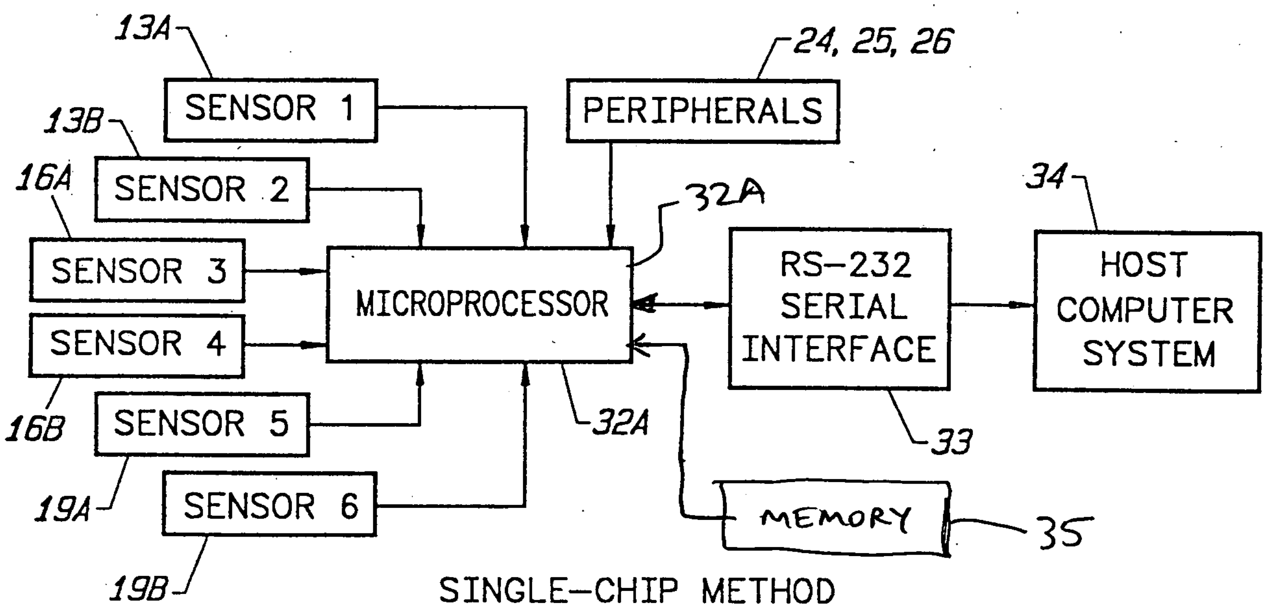
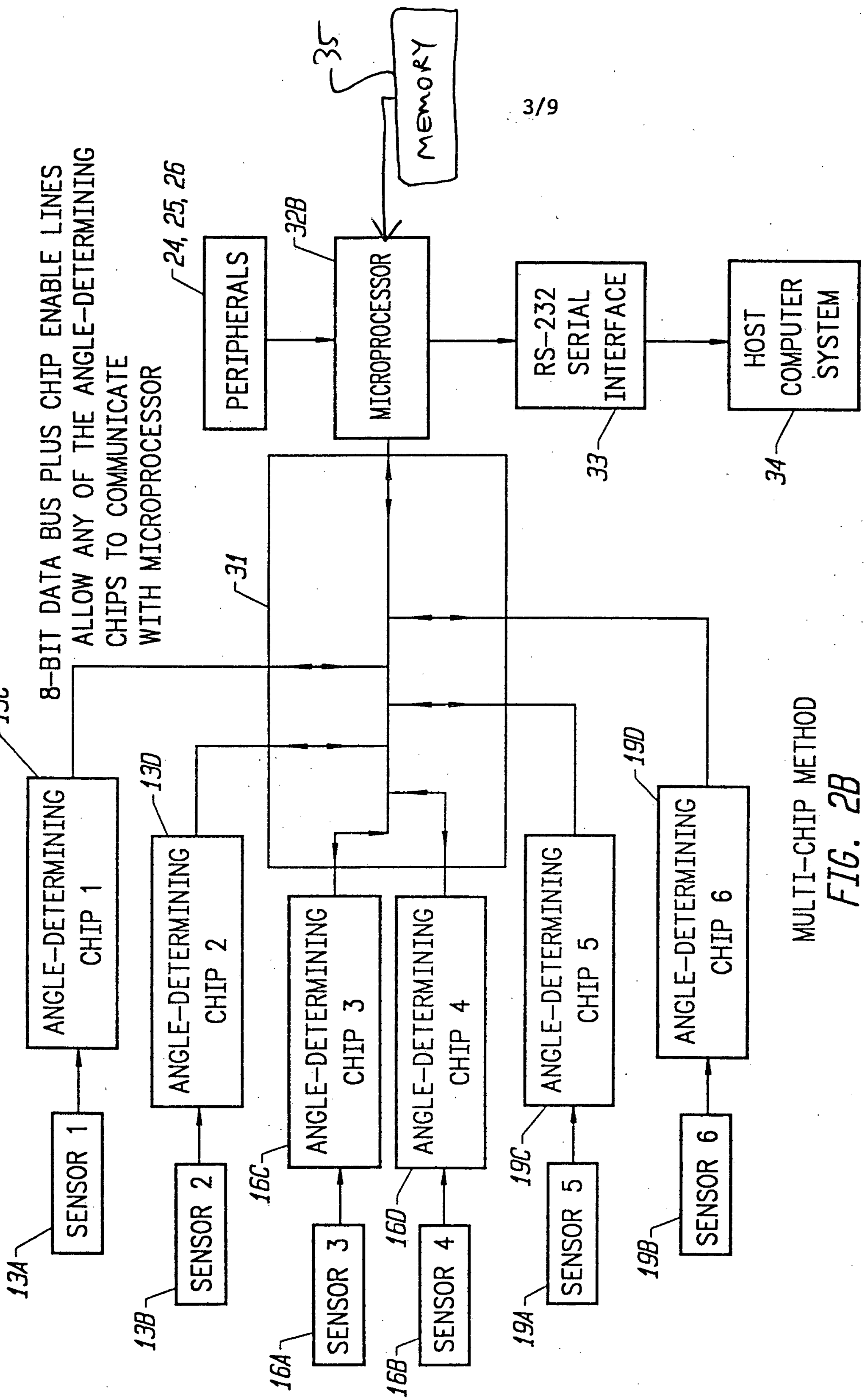

A3
~~AXIS 3~~
A4
~~AXIS 4~~
15
A2
~~AXIS 2~~
17
14
A5
~~AXIS 5~~
19A
16A
16B
27
25'
A1
~~AXIS 1~~
13A
12
13B
19B
18
11
25
24
20
11'
F
~~AXIS 6~~
A6
21
26'
23
22
28
32'
26
32A OR 32B
35
SENSOR AND FORCE SIGNALS
MICROPROCESSOR
MEMORY
34''
34'
HOST COMMAND
40
DISPLAY APPARATUS
COMPUTER
34

FIG. 1



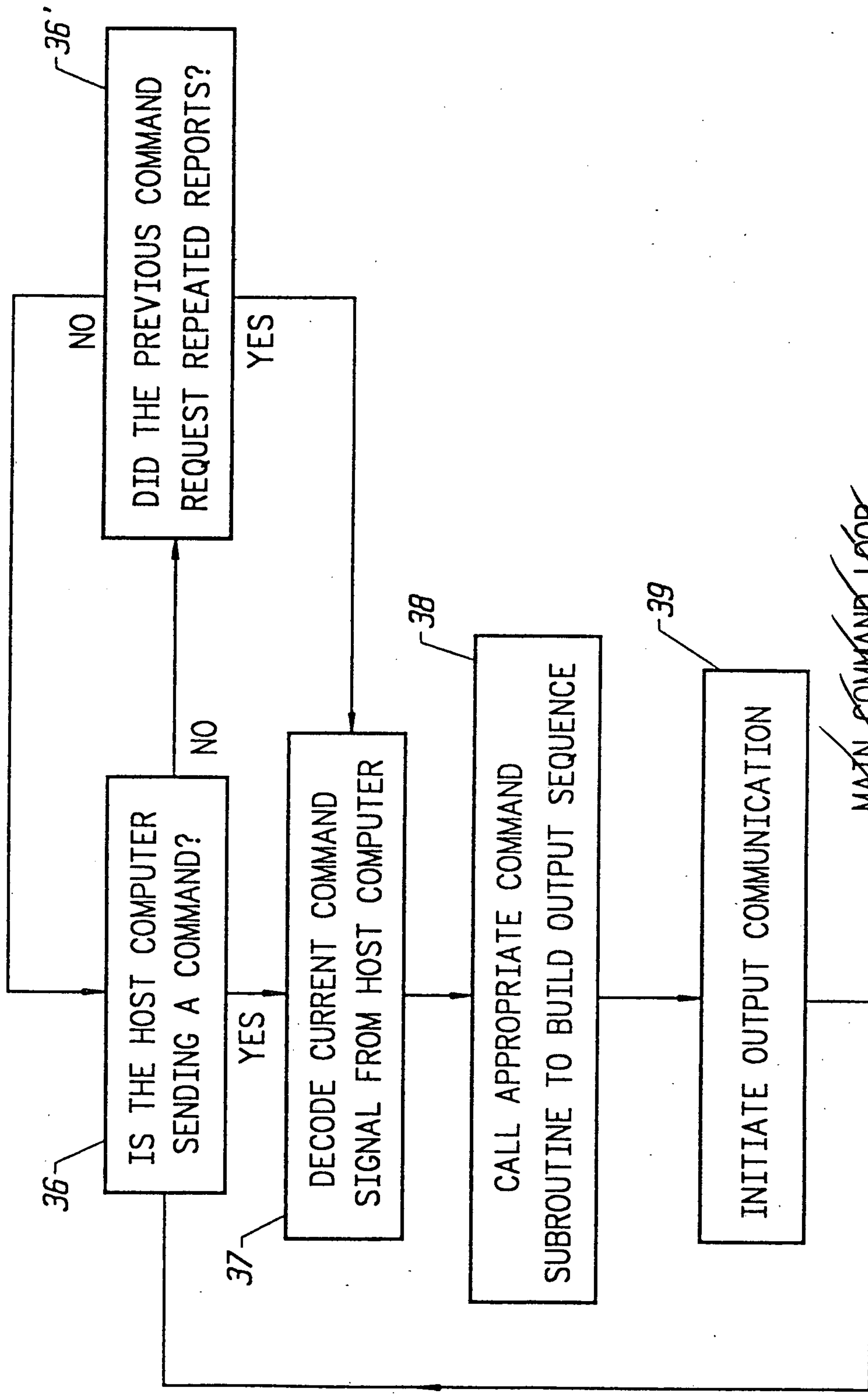
SINGLE-CHIP METHOD

FIG. 2A



MULTI-CHIP METHOD

FIG. 2B



~~MAIN COMMAND LOOP~~

FIG. 3

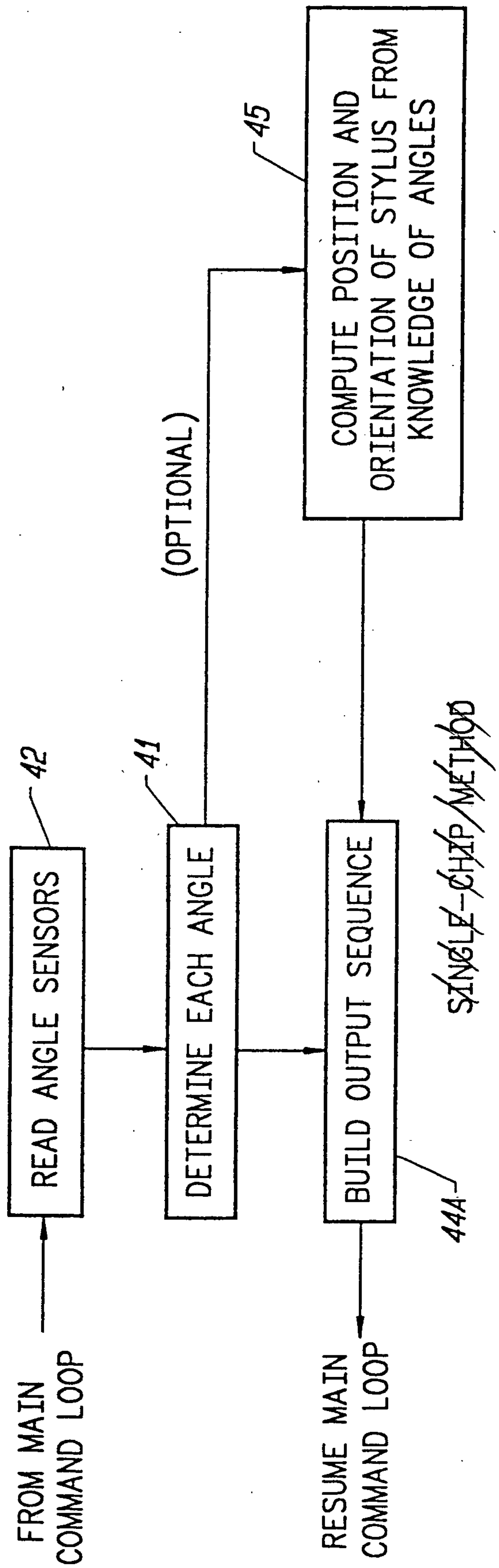

FROM MAIN COMMAND LOOP
READ ANGLE SENSORS
42
DETERMINE EACH ANGLE
41
(OPTIONAL)
COMPUTE POSITION AND ORIENTATION OF STYLUS FROM KNOWLEDGE OF ANGLES
45
BUILD OUTPUT SEQUENCE
44A
RESUME MAIN COMMAND LOOP
~~SINGLE-CHIP METHOD~~

FIG. 4B

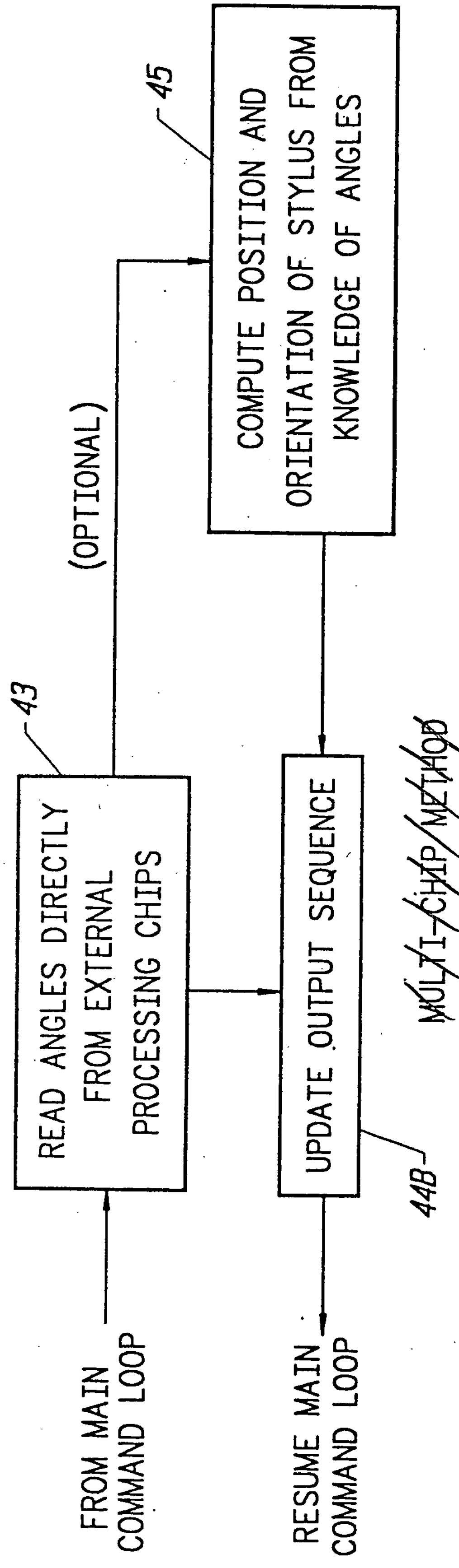
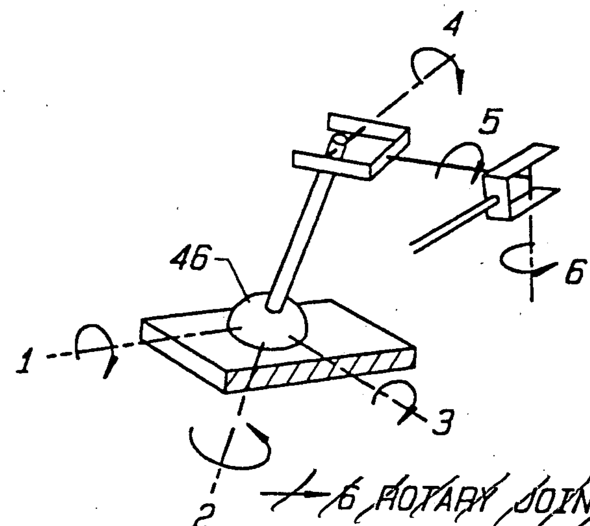
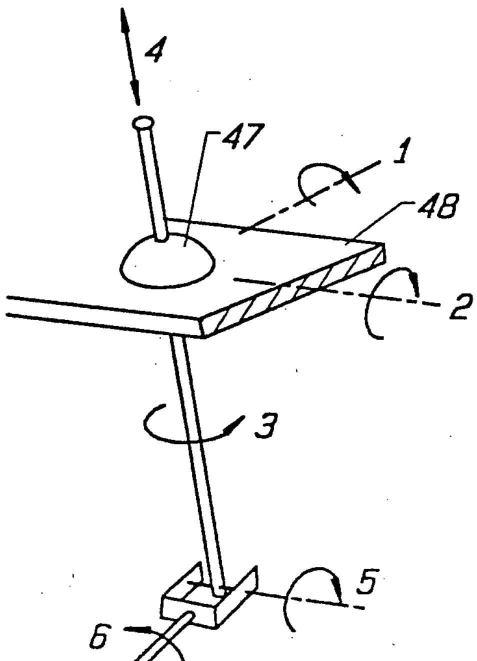

FROM MAIN COMMAND LOOP
READ ANGLES DIRECTLY FROM EXTERNAL PROCESSING CHIPS
43
(OPTIONAL)
COMPUTE POSITION AND ORIENTATION OF STYLUS FROM KNOWLEDGE OF ANGLES
45
UPDATE OUTPUT SEQUENCE
44B
RESUME MAIN COMMAND LOOP
~~MULTI-CHIP METHOD~~

FIG. 4A



~~6 ROTARY JOINTS~~

FIG. 5

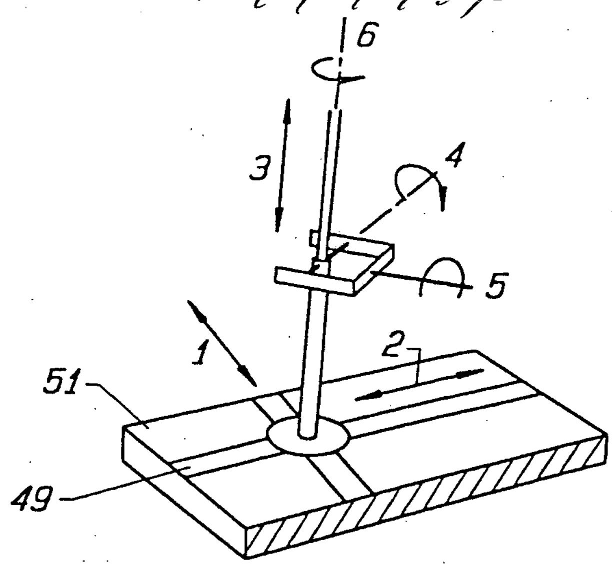


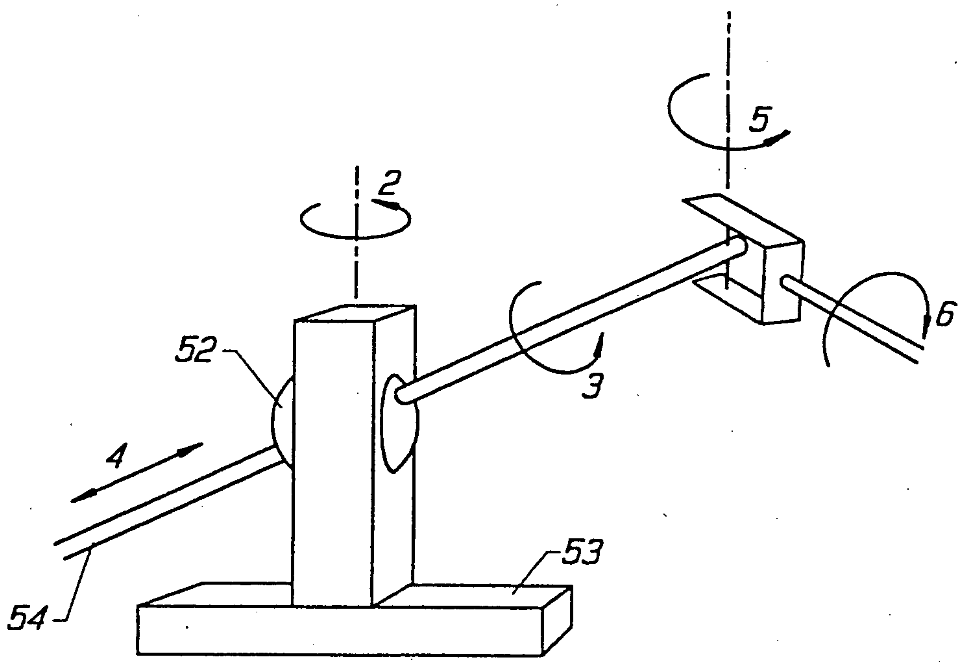
~~5 ROTARY JOINTS~~
~~1 LINEAR JOINT~~

FIG. 6

FIG. 7

~~3 ROTARY JOINTS~~
~~3 LINEAR JOINTS~~





~~5 ROTARY JOINTS~~
~~1 LINEAR JOINT~~

FIG. 8